17662 1

GMCS Temporary Treatment and Conveyance System

Site R - Sauget Area 2

Sauget, Illinois

INTRODUCTION

Prior to the installation of the final Groundwater Migration Control System (GMCS) at Site R of Sauget Area 2, Solutia Inc. (Solutia) plans to perform a demonstration study (pilot test) of treatment of extracted groundwater. The pilot test will operate a single well at a maximum flow rate of 300 gallons per minute (gpm). The test will require approximately 2,800 feet of pipe as conveyance between the wellhead, temporary treatment system, and sewer discharge point. Groundwater will be treated and filtered through a mobile granular activated carbon system specified and supplied by Advent Group Inc. (Advent). The temporary treatment system for the pilot test will be installed approximately 900 feet downstream of the wellhead (EW-2). The temporary conveyance system is to remain operational until the permanent conveyance system is in operation, approximately nine to twelve months after completion of the pilot test. This document summarizes the layout and design of the temporary treatment and conveyance system.

TREATMENT SYSTEM

The activated carbon treatment system is designed to treat groundwater by removing total organic carbon (TOC), which is composed of a variety of aliphatic and aromatic compounds. Characterization data from 1992 indicates that the average TOC concentration in the groundwater is approximately 300 milligrams per liter (mg/L). The treatment system has a maximum pressure rating of 50 to 65 pounds per square inch (psi) for the temporary unit. Attachment A provides a schematic of the treatment unit and details of the treatment process to be used during the pilot test.

CONVEYANCE SYSTEM MATERIALS AND METHODS

A submersible pump (Grundfos Model 300S200-5 rated at 20 horsepower) will be used to remove groundwater from extraction well EW-2 and pump it to the temporary treatment unit at Site R.

Four-inch diameter welded high density polyethylene (HDPE) pipe will be used to convey extracted groundwater from the well to the discharge manhole. CPchem DriscoPlex 4000 (or equivalent) SDR 21 HDPE pipe will be used for all sections of the piping. Fabricated fittings will be used to make small radius bends and all joints will be heat-fused per the pipe manufacturer's specifications. DriscoPlex 4000 pipe can be used in above-grade installation, below-grade (directional boring) installation, or used as a slip-lining in existing pipes. DriscoPlex 4000 SDR 21 HDPE pipe has a pressure rating of 80 psi.

Where suitable conditions exist, the HDPE pipe will be installed approximately one-foot below grade using a plowing/planting method where a trench is excavated, the pipe laid, and the trench backfilled using a trenching machine or plow. This method of installation will insulate the pipe from rapid thermal changes, but will also allow easy dismantling when the temporary system is no longer needed. Below-grade installations better insulate the pipe from rapid thermal changes that can be experienced in above-grade installations.

The 4-inch HDPE pipe will be installed directly on the ground surface where it cannot be installed with the plowing/planting method. Small debris and obstacles will be removed from the path of the surface piping to allow the pipe to be evenly bedded on the ground surface. For ease of installation and dismantling, clean sand will be mounded on top of the pipe at 50 foot intervals to anchor the pipe to the ground (see Detail on Figure 2). Additional sand will be used to anchor all surface bends, where insufficient cover is available to anchor plowed/planted sections, and as determined during installation in the field.

In order to reduce system pressures in the treatment unit (maximum allowable pressure: 50 psi), an equalization tank and booster pump will be used, to pump water exiting the treatment unit to the discharge manhole. To be effective in reducing the operational pressure required to convey water from the extraction well to the filter, discharge from the filter is conveyed immediately to an equalization tank, which reduces the system pressure to atmospheric pressure. The treated water will then be pumped from the tank to the sewer discharge manhole through the use of a booster pump. This set-up is commonly used in surface water conveyance systems. The specified booster pump is a Goulds model 3656 pump with a 6.375 inch impeller operating at 14 horsepower. Details of the equalization tank and booster pump are provided in Attachment B.

Subsurface installation will be required at the Pillsbury Avenue crossing so as not to interfere with the roadway or traffic pattern. Directional boring methods will be used to install the HDPE pipe beneath Pillsbury Avenue. The maximum depth of the underground bore and piping should not exceed ten feet below grade.

A slip-lining technique will be used to install the 4-inch HDPE pipe inside an existing six-inch steel pipe located just east of the levee.

CONVEYANCE SYSTEM COMPONENTS

The conveyance system sections labeled on Figure 1 are described in detail below:

Section A

This section consists of approximately 900 feet of 4-inch HDPE pipe, installed using the planting/plowing method or above-grade, according to the methods outlined above. Section A connects the extraction well to the treatment unit. The temporary pipe will be directly flanged to the extraction wellhead piping.

Section B

This section is comprised of the temporary treatment unit, equalization tank and booster pump. A schematic of the temporary treatment unit is shown in Attachment A. Details of the booster pump and associated equalization tank are described in Attachment B.

Section C

This section consists of a total of approximately 1,100 feet of 4-inch HDPE pipe, installed using the planting/plowing method or above-grade, according to the methods outlined above. Three 90-degree horizontal elbows will be used to make the necessary bends in Section C, as shown on Figure 2. The first bend occurs at the intersection of the pipe and Riverview Avenue, where the pipe is diverted to the east along Riverview Avenue. The second bend is located near the intersection of Riverview Avenue with Pillsbury Avenue, where the pipe is diverted to the south. A 100-foot section of pipe will extend south of Riverview Avenue to the west side of the directional bore under Pillsbury Avenue. The third bend directs the pipe to the east and into alignment with the underground bore section.

Section D

Section D consists of an underground bore which extends the 4-inch HDPE pipe from ground surface on the west side of Pillsbury Avenue, under the roadway and daylights on the east side of the road. The bored section will be approximately 100 feet long with a maximum depth of ten feet below grade at its center. The boring and pipe will daylight west of the levee and will not penetrate any part of the levee.

Section E

This section consists of a total of approximately 125 feet of 4-inch HDPE pipe, installed above-grade according to the methods outlined above, except where special requirements for the levee crossing are needed. The pipe will extend up and over the concrete flood control wall and will be supported by a temporary, free-standing steel bridge. The steel bridge will be anchored at its base and will not require destructive connection to the flood wall (pending permit approval). Four 90-degree vertical elbows will be used to make the necessary bends over the flood wall. On the levee access road, the 4-inch HDPE pipe will be installed inside a 6-inch steel pipe to protect the HDPE pipe from vehicular traffic. Crushed gravel will be placed on top of the steel casing to provide a shallow ramp (20H:1V) for vehicles to cross the pipe. A profile view of this section is shown on Figure 2, Detail A. A front view of the free-standing steel support bridge is shown on Figure 2, Detail B.

Section F

This section consists of approximately 300 feet of 4-inch HDPE slip-lined inside the existing 6-inch steel pipe that extends under the railroad tracks. At a point approximately 300 feet east of the railroad tracks, the steel pipe will be broken and a 90-degree vertical elbow will be installed on the four-inch HDPE liner to bring the pipe back to ground surface. A second 90-degree vertical elbow will be used to direct the pipe north toward the discharge manhole. The existing steel pipe is buried between five and seven feet below grade. An excavation will be required to access the pipe on its east end. If the pipe is buried deeper than four feet below grade, proper shoring of the access excavation will be required per State and Federal Regulations. Detail C on Figure 2 shows this section in profile view.

Section G

This section consists of a total of approximately 260 feet of four-inch HDPE pipe, installed using the planting/plowing method or above-grade, according to the methods outlined above. The surface piping will discharge directly into an existing sewer manhole. A six-foot drop pipe and 90-degree vertical elbow will be used to direct flow into the existing 12-inch sewer at the base of the manhole. The existing 12-inch combined sewer transmits water from local businesses to the American Bottoms Regional Wastewater Treatment plant located nearby. Detail D on Figure 2 shows the discharge.

HYDRAULIC DESIGN

The Grundfos Model 300S200-5 (20 HP) pump which will be used to pump the well is capable of pumping 370 gpm at a total dynamic head of 133 feet. The expected pressure build-up in the treatment filter unit is estimated at 13.2 psi. The Goulds model 3656 pump with a 6.375-inch impeller operating at 14 horsepower will be used as a booster to pump water to the discharge manhole. Downstream of the booster pump, the maximum pressure in the system is estimated at 36.3 psi. Both of these values are below the pressure rating for the SDR 21 HDPE pipe (80 psi).

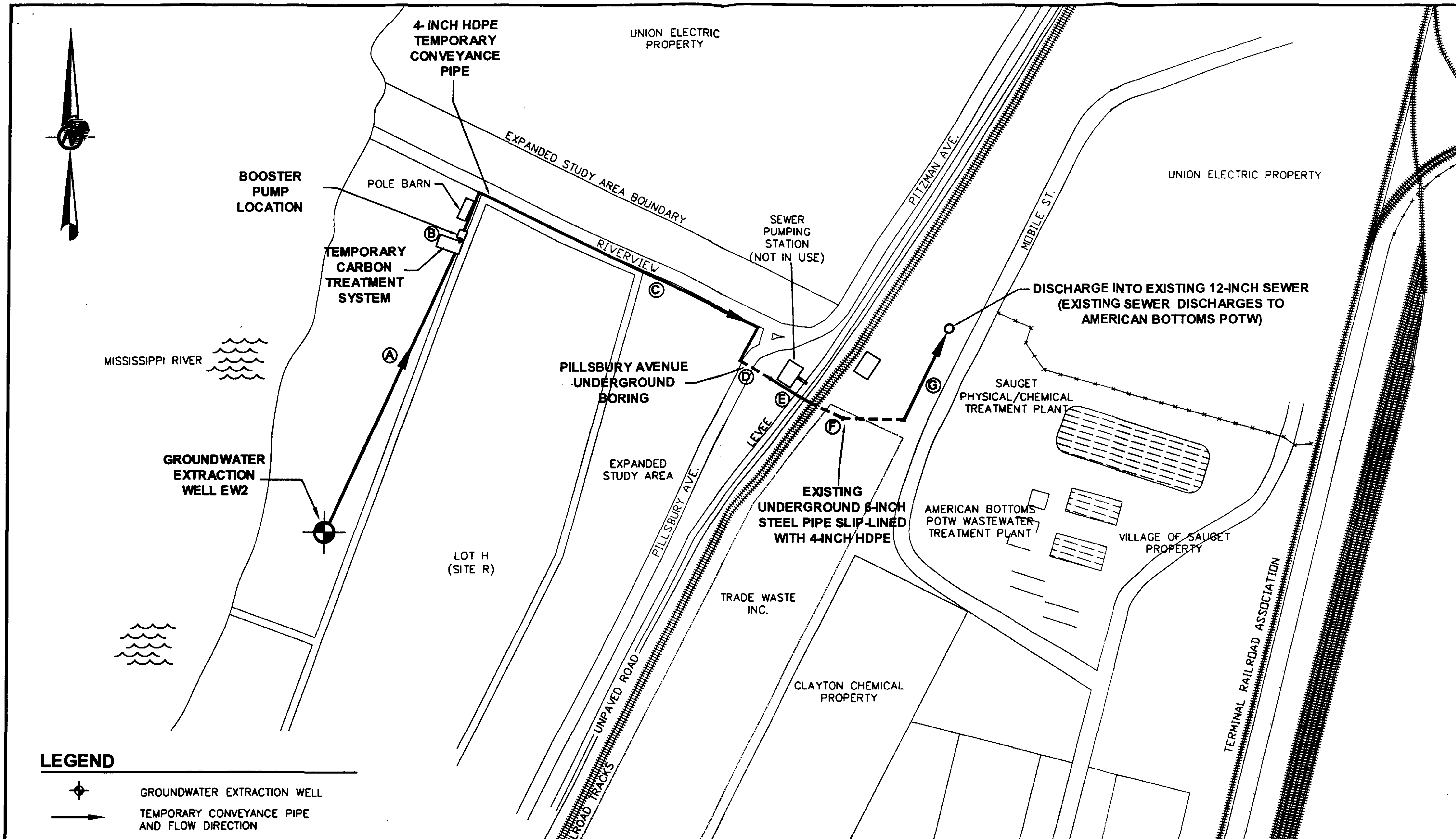
During operation, the pump flow rates should be increased slowly to the maximum rate of 300 gpm in order to avoid water hammer damage to the filter system. Combination air vacuum/release valves will be required to protect the system from water hammer and ensure maximum hydraulic efficiency of the pipeline. These release valves will be located at the following locations within the conveyance system:

- immediately upstream of the treatment filter system;
- the 90-degree horizontal bend transitioning flow along Riverview Avenue;
- the start of the Pillsbury Avenue bore;
- the top of the levee wall; and
- ground level at the intersection with the discharge manhole.

Check valves, gate valves, and flow meters will also be required at specified locations immediately upstream and downstream of the 550 gallon equalization tank as shown in Figure 4 of Attachment B. The check valves prevent reverse flows through the filtration system and the booster pump, which could damage these units. The gate valves and flow meters are used to balance inflows and outflows to the equalization tank, thereby preventing excess wear to the well and booster pumps caused by excessive on and off cycling.

It should be emphasized that some of the details for the configuration (e.g.; number of bends, distance between specified locations, etc.) of the temporary system may need to be adjusted during installation.

FIGURES



LEGEND

GROUNDWATER EXTRACTION WELL

TEMPORARY CONVEYANCE PIPE AND FLOW DIRECTION

Ⓐ CONVEYANCE SYSTEM SECTION ID

NOTES

1. Temporary 4-inch HDPE pipe will be installed on or just below ground surface except at Pillsbury Avenue boring, and through the existing underground 6-inch steel pipe east of the levee.

0 500 1000

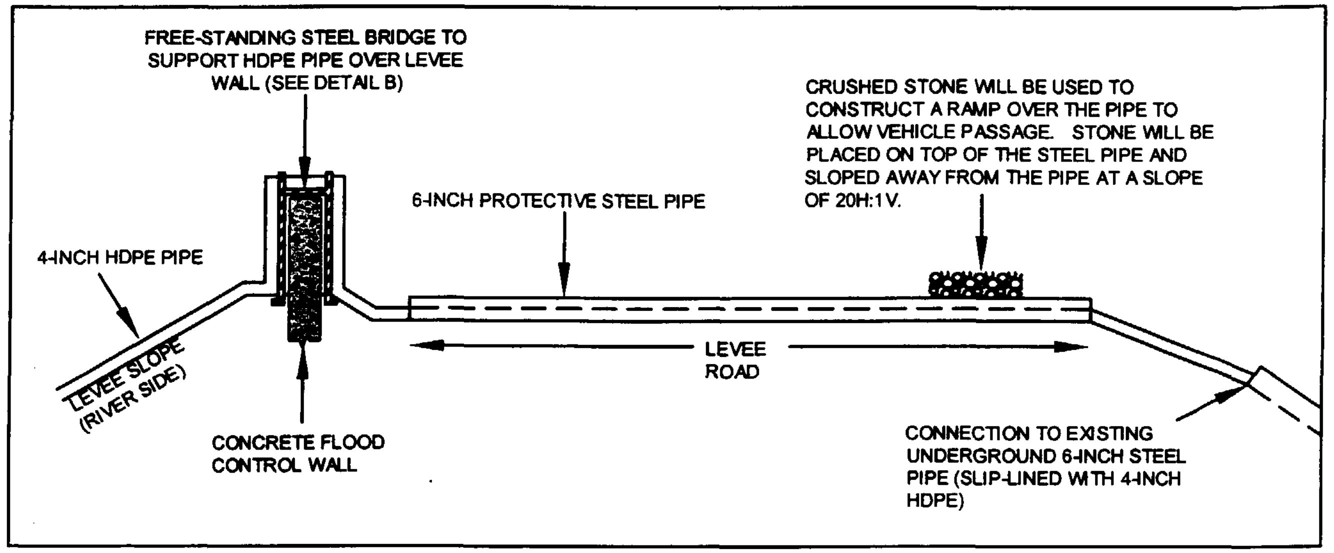
APPROXIMATE SCALE IN FEET

Golder Associates, St. Louis, Missouri	SCALE: AS SHOWN	TITLE: GMCS TEMPORARY CONVEYANCE SYSTEM PLAN	
	DATE: JAN2002		
	DESIGN: MNH	PROJECT: SAUGET AREA 2, SITE R, GMCS	DWG/FIG No. 1
FILE No. 0239606.201	CADD: JAP		
	CHECK: MNH	SAUGET, ILLINOIS	
PROJECT No. 023-9606 / REV. 2	REVIEW: MLS		

A / 2 LEVEE CROSSING

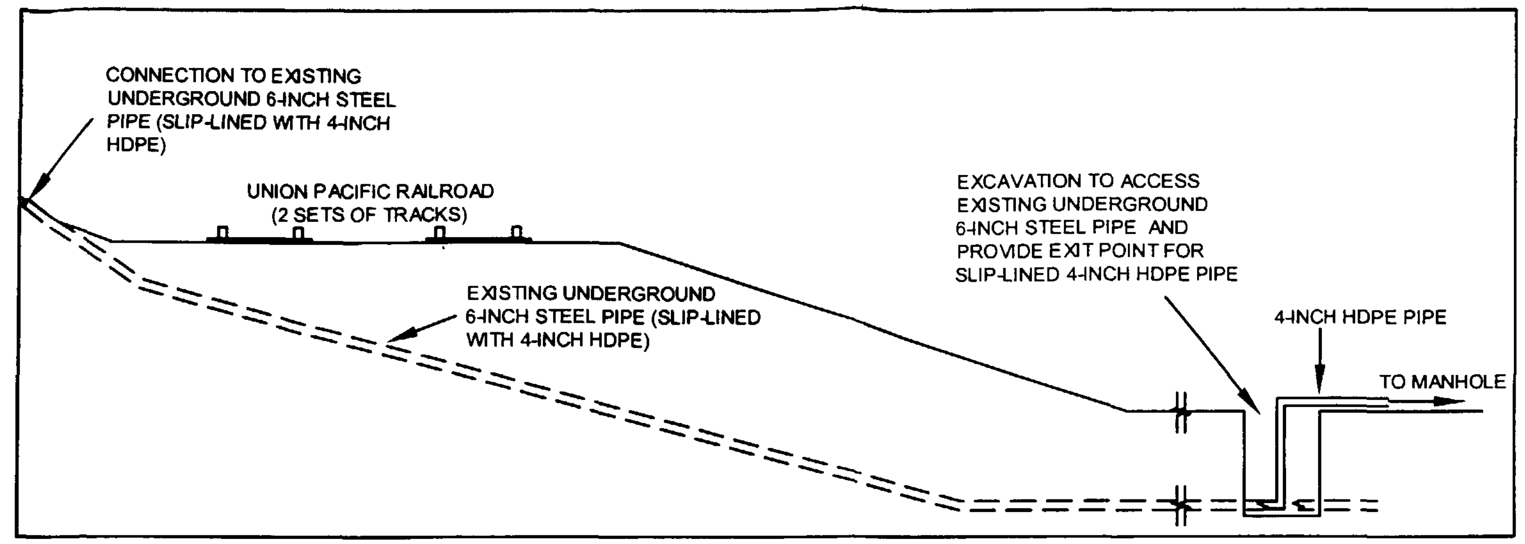
5 0 5

SCALE: 1" to 5' FEET



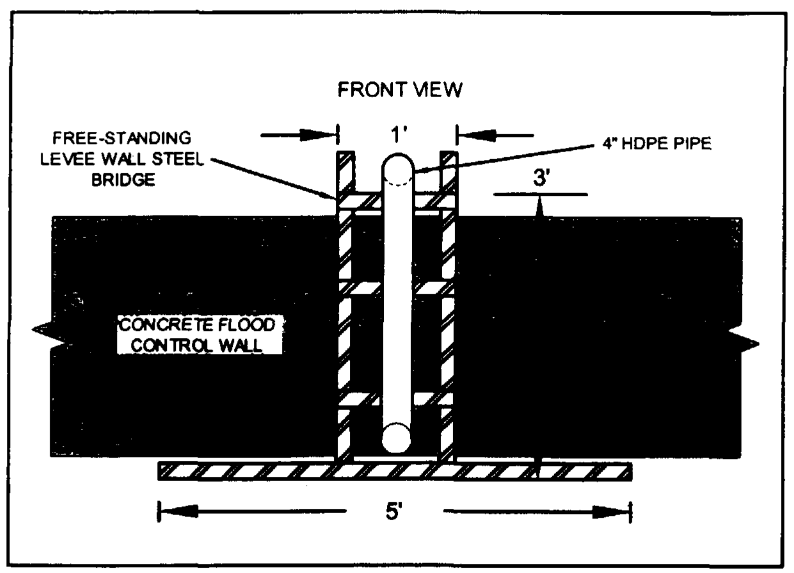
C / 2 EXISTING 6-INCH STEEL PIPE

Not to Scale



B / 2 FREE-STANDING LEVEE WALL STEEL BRIDGE

Not to Scale



D / 2 DISCHARGE INTO EXISTING SEWER

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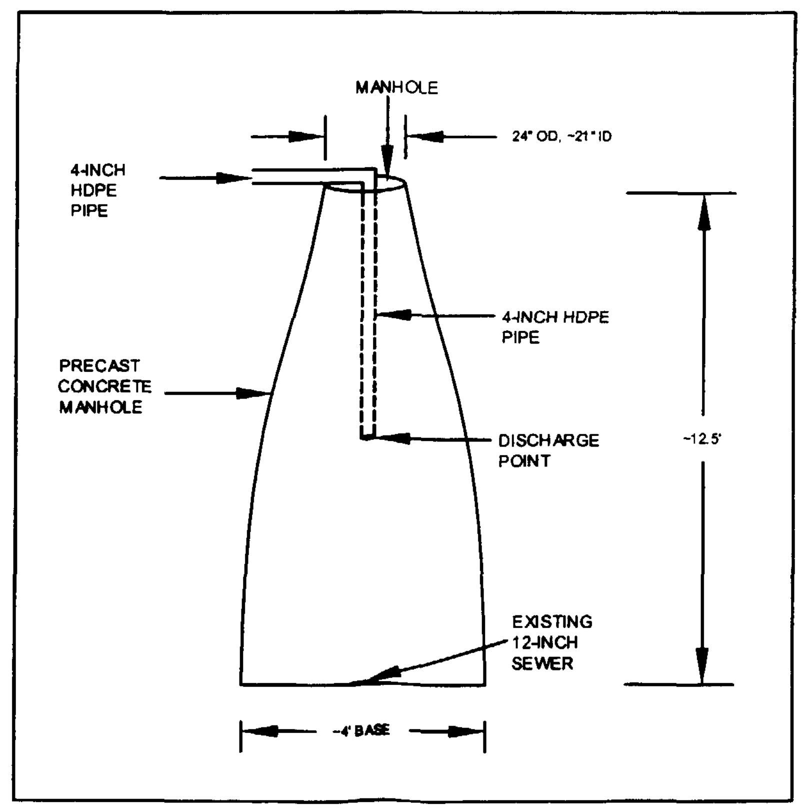
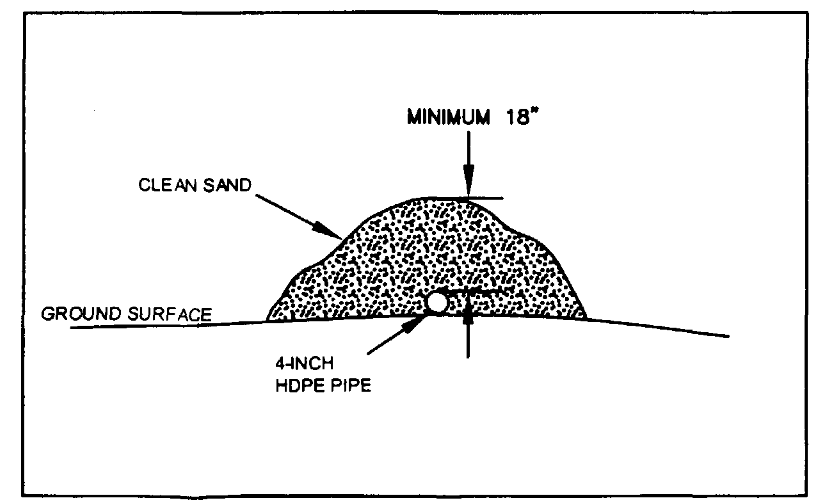


E / 2 SURFACE PIPE ANCHOR DETAIL

Not to Scale



NOTES

1.) Excavation may require shoring per regulations.

2.) Manhole will be fitted with temporary cover.

3.) Base of free standing steel support to be covered with crushed stone (minimum thickness of 12-inches).

REV	DATE	DES	REVISION DESCRIPTION	CADD	CHK	RVW
1	01/17/03		TEXT EDITS			

PROJECT: SAUGET AREA 2, SITE R, GMCS

Sauget, Illinois

TITLE: GMCS TEMPORARY CONVEYANCE SYSTEM DETAILS

Golder Associates
St. Louis, Missouri

PROJECT No.		023-9606	FILE No.	0239606.202
DESIGN	MNH	01/10/03	SCALE AS SHOWN	REV. 1
CADD	MSL	01/13/03		
CHECK	MNH	1/13/03	2	
REVIEW	MA	1/27/03		

Drawing file: 013-9606.202 GMCS Temporary Conveyance System- Detail.dwg

ATTACHMENTS

ATTACHMENT A

SYSTEM BULLETIN

CALGON

CALGON CARBON CORPORATION

MOBILE MODEL 8

MODULAR CARBON ADSORPTION SYSTEM SHIPPED FULLY ASSEMBLED

DESCRIPTION

The Calgon Carbon Mobile Model 8 is an adsorption system designed for the removal of dissolved organic contaminants from liquids using granular activated carbon. The modular design concept allows selection of options or alternate materials to best meet the requirements of the customer's site and treatment application.

The Mobile Model 8 system is delivered as a completely fabricated system with adsorbers and compact center piping network, requiring only a single crane lift for site installation. The unit can be shipped prefilled with granular activated carbon. The pre-engineered Mobile Model 8 design assures that all adsorption system functions can be performed with the valves and equipment process design that is shipped to the site.

The process piping valve network for the Mobile Model 8 offers operation of the adsorbers in parallel or series flow (with either adsorber placed in the lead stage). The piping and valve arrangement can also isolate either adsorber from the process flow. This permits carbon exchange or backwash operations to be performed on one adsorber without interrupting treatment through the remaining carbon bed.

The underdrain design provides for the efficient collection and uniform distribution of treated water and the uniform distribution of backwash water. The Mobile Model 8 system is designed for use with Calgon Carbon's closed loop carbon exchange service. Using specially designed trailers, spent carbon is removed from the adsorbers in a closed loop and returned to Calgon Carbon for reactivation. The transfer is accomplished without exposure of operating personnel to contaminated liquid. The trailers also recharge the adsorbers with fresh activated carbon.

OPERATING CONDITIONS

System flow(at 8 gpm/ sq. ft.)	400 gpm (series) 800 gpm (parallel)
Carbon per adsorber (max. nonbackwashable)	10,000lbs. (4540 kg)
Pressure rating	75 psig (517 kPa)
Pressure relief	Graphite rupture disk (71 psig)
Vacuum rating	Full vacuum
Temperature rating	140°F maximum (60°C)
Backwash rate	600 gpm per adsorber (at 12 gpm/sq. ft.)
Backwash expansion per adsorber with 10,000 lbs. carbon	0%
Backwash expansion per adsorber with 8,000 lbs. carbon	25%
Backwash expansion per adsorber with 6,500 lbs carbon	50%
Carbon transfer	Air pressure slurry transfer
Utility air (for carbon transfers) (reduce to 15 psig for trailer)	100 scfm at 30 psig
Utility water (for carbon transfers)	100 gpm at 30 psig
Freeze protection	None provided; enclosure or protection recommended.

SYSTEM SPECIFICATIONS

Standard Features:

Carbon adsorbers:

- Carbon steel ASME code stamped pressure vessels.
- Internal vinyl ester lining (Plasite 4006, 25 to 35 mils nominal) for potable water and most liquid applications. (Recommended)
- Polypropylene slotted nozzles for water collection and backwash distribution.
- 20" round manway for internal access.

Standard adsorption system piping:

- 6" schedule 40 carbon steel process piping with cast iron fittings accommodates lead/lag flow.
- Cast iron butterfly valves for process piping.
- 3" carbon line with 4" hose adapter fitting.

System external coating:

- Epoxy mastic paint

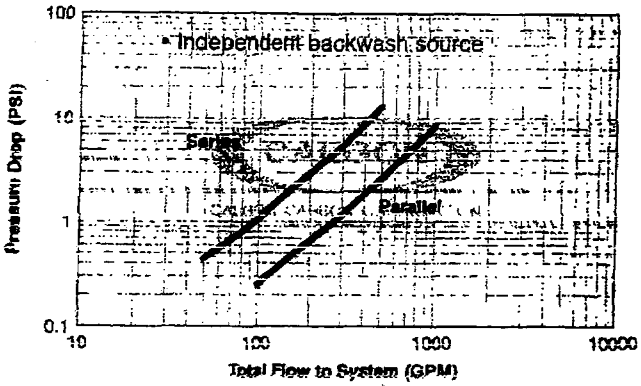
Other Standard Features:

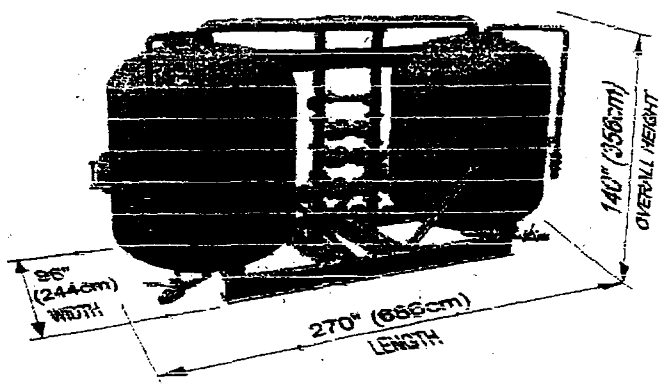
- System platform skid for ease of field installation.
- Stainless steel pipe for carbon discharge.
- Full bore stainless steel ball valves for carbon fill and discharge pipelines
- Two in-bed sample taps for each adsorber.
- Pressure gauges (3). Piping sample taps (3).
- Vessel pressure rating 75 lbs.
- Seismic Zone 4 construction.
- 8" nozzle per adsorber, for dry filling of carbon material.
- Independent backwash source

Available Features:

- Pre-loaded carbon fill
- Differential pressure switches.
- Other lining/painting materials.
- Alternate manway sizes.
- Process pipe sizes and materials of construction with redesign.
- Pressure relief valves.
- Alternate underdrain designs available with redesign.
- Carbon traps.
- Vessel pressure rating -125 lbs.

Mobile 8 Pressure Drop
Filtrasorb 300 Carbon (55°F)
6" Sch. 40 Carbon Steel Pipe





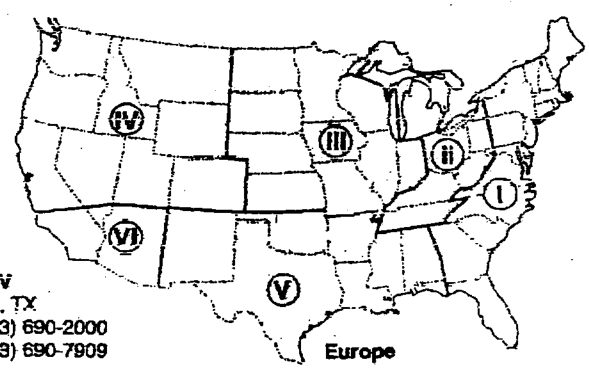
DIMENSIONS AND FIELD CONNECTIONS

Adsorber vessel diameter:	8ft. (2440 mm.)
Process Pipe:	6 in.
Process Pipe connection:	125# ANSI flange
Utility water connection:	3/4 in. hose connection
Utility air connection:	3/4 in. hose connection
Carbon hose connection:	4 in. Kamlock type
Backwash connections:	6 in. flange
Adsorber maintenance access	20" round flanged manway
System shipping weight	21,600 lbs. (empty) (9818 kg)
Shipping weight (with max 20,000 lbs. carbon)	41,600 lbs. (18,909 kg)
System operating weight (with 20,000 lbs.carbon)	83,500 lbs.(37,955 kg)

SAFETY MESSAGE

Wet activated carbon preferentially removes oxygen from air. In closed or partially closed containers and vessels, oxygen depletion may reach hazardous levels. If workers are to enter a vessel containing carbon, appropriate sampling and work procedures for potentially low oxygen spaces should be followed, including all applicable federal and state requirements.

1-800-4-CARBON



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Fax (908) 526-2467

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Tel (412) 787-6700
1-800-4-CARBON
Fax (412) 787-6676

Region III
Lisle, IL
Tel (708) 505-1919
Fax (708) 505-1936

Region IV
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Fax (415) 344-2029

Region V
Houston, TX
Tel (713) 690-2000
Fax (713) 690-7909

Region VI
Carlsbad, CA
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Fax (619) 431-8169

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Fax 32 2 770 93 94

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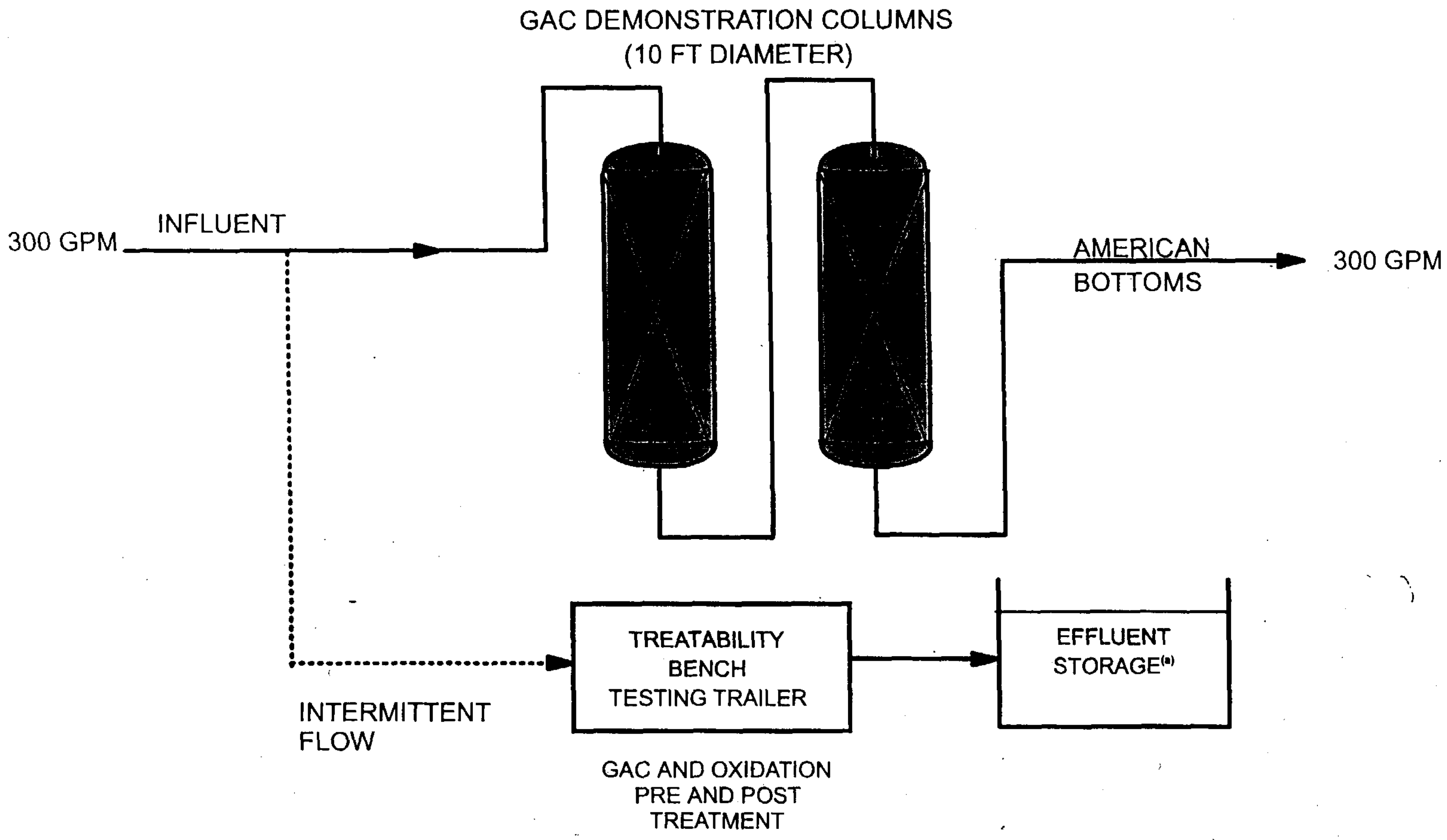
Fax (412) 787-4523

Singapore/Asia Pacific
Calgon Carbon Corp.
Tel (65) 221-3500
Fax (65) 221-3554

Calgon Carbon Corporation's activated carbon products are continuously being improved and changes may have taken place since this publication went to press.

CALGON

CALGON CARBON CORPORATION



Note:

(a) Effluent will be treated by GAC columns at conclusion of demonstration study before discharge to American Bottoms.

Prepared For: SOLUTIA SOLUTIA INC. William G. Krummrich Plant	Prepared By: THE ADVENT GROUP, INC. NASHVILLE, TENNESSEE	**TREATABILITY FLOW SCHEMATIC** 02607\treatability flow schematic 04-Nov-02

ATTACHMENT B

Golder Associates	Subject Solutia	Made by TML	Job No 023-9606
	Extraction Well Relocation	Checked by MNH	Date 1/17/03
	Pump System Design	Approved by	Sheet No 1 of 2

OBJECTIVE:

Specify a booster pump to be installed downstream of the Advent filtration system for Solutia, Inc. (Solutia). This pump is to be installed on a 4 inch diameter high density polyethylene (HDPE) pipeline downstream of an equalization tank meant to reduce the line pressure through the filtration system coming from the well. Check line pressures at various locations in the 4 inch diameter HDPE pipeline to ensure that they don't exceed the maximum allowable pressure rating of the pipeline.

Check the currently specified well pump to ensure that it operates within the desired performance range and that the line pressure it generates doesn't exceed the maximum allowable operating pressure of the Advent filtration system.

Provide installation details of the equalization tank / booster pump system. In addition, specify locations in the 4 inch HDPE pipeline where combination air vacuum/release valves are required to ensure proper operation of the pipeline and protect the system from water hammer.

METHOD:

Drawdown of the existing groundwater table in extraction well EW2 was computed using the Darcy equation as listed in Hydraulic Engineering (Roberson, Cassidy, & Chaudhry 1995).

System rating curves for both the booster and well sides of the equalization tank are constructed by solving the one-dimensional energy equation for total dynamic head (pump head). Bend, expansion, contraction, and minor losses are computed by multiplying the velocity head by an appropriate energy loss coefficient taken from Hydraulic Engineering (Roberson, Cassidy, & Chaudhry 1995). Energy losses through the Advent filtration system are assumed to equal 30 feet. Friction losses are computed using the Hazen-Williams equation listed in Civil Engineering Reference Manual (Lindeburg 2001) and an assumed "C" coefficient.

The system curves were then plotted over the pump curves provided by the manufacturers of the booster and well pumps specified to determine the operating points of the two different hydraulic systems. The operating point determines the maximum capacity system flow rate and total dynamic head that must be provided by the pumps.

The energy equation was then resolved for line pressure at various points in both sides of the pumping system.

CONCLUSIONS/RESULTS:

The layout of the pumping system is illustrated on Figure 1. Descriptions of each of the lettered terms in Figure 1 are provided in Attachment 1.

Computation of the system curve for the specified booster pump, a Goulds model 3656 pump with a 6.375-inch impeller operating at approximately 14 horsepower (hp), is provided in Attachment 2. Figure 2 illustrates the system and pump curves and shows that the maximum capacity system flow rate downstream of the equalization tank is 335 gallons per minute (gpm) and that the total dynamic head (TDH) required by the pump is 95 feet.

A check of operating line pressure at various points in this part of the pumping system, provided in Attachment 2, shows that the maximum expected line pressure is 36.3 pounds per square inch (psi) which is less than the maximum allowable pressure in the 4 inch HDPE pipeline: 80 psi.

Computation of the system curve for the specified well pump, a Grundfos model 300S200-5 pump operating at 20 hp, is provided in Attachment 3. Figure 3 illustrates the system and pump curves and shows that the maximum capacity system flow rate upstream of the equalization tank is 370 gallons per minute (gpm) and that the total dynamic head (TDH) required by the pump is 133 feet. A check of operating line pressure at the Advent filtration system, provided in Attachment 3, shows that the maximum expected line pressure is 13.2 psi which is less than the maximum allowable pressure in the Advent filtration system: 50 psi.

A summary of the expected water, brake, and input horsepower for the two pumps along with an estimate of overall system efficiency is provided in Attachment 4. An installation detail of the booster pump / equalization tank assembly is provided in Figure 4. Note that the two gate valves upstream and downstream of the equalization tank are used in conjunction with their respective flow meters to balance the inflow and outflow rates into the tank at approximately 300 gpm.

Referring to Figure 1 and the location notes in Attachment 1, installation of combination air vacuum/release valves are recommended in the following locations:

- B (immediately upstream of the Advent filtration system),
- D (at the first 90° horizontal bend transitioning flow along Riverview drive),
- G (start of the Pitzman Avenue bore),
- K (top of the levee wall), and
- Q (ground level at the intersection with the discharge manhole). Installation of a combination air vacuum/release valve at this location is particularly important because the system analysis in Attachment 2 shows the potential for sub-atmospheric pressure at this location.

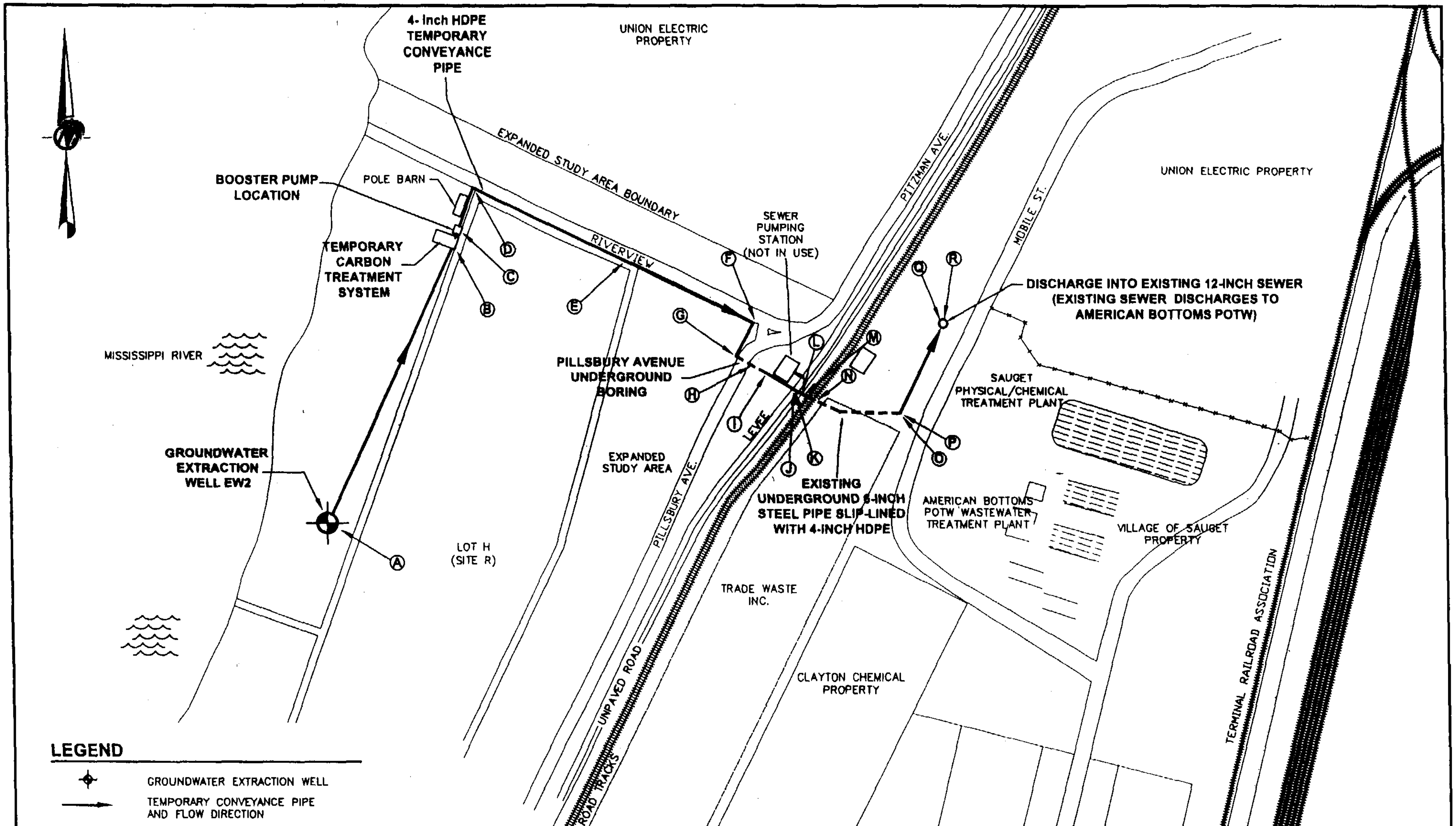
In addition, installation of a check valve in the 4 inch HDPE pipeline at groundwater extraction well EW2 is recommended.

REFERENCES:

Lindeburg, M. R. 2001. *Civil Engineering Reference Manual, 8th Edition*. Belmont, CA: Professional Publications, Inc.

Roberson, J. A., Cassidy, J. J., and Chaudhry, M. H. 1995. *Hydraulic Engineering*. New York, NY: John Wiley & Sons, Inc.

FIGURES



LEGEND

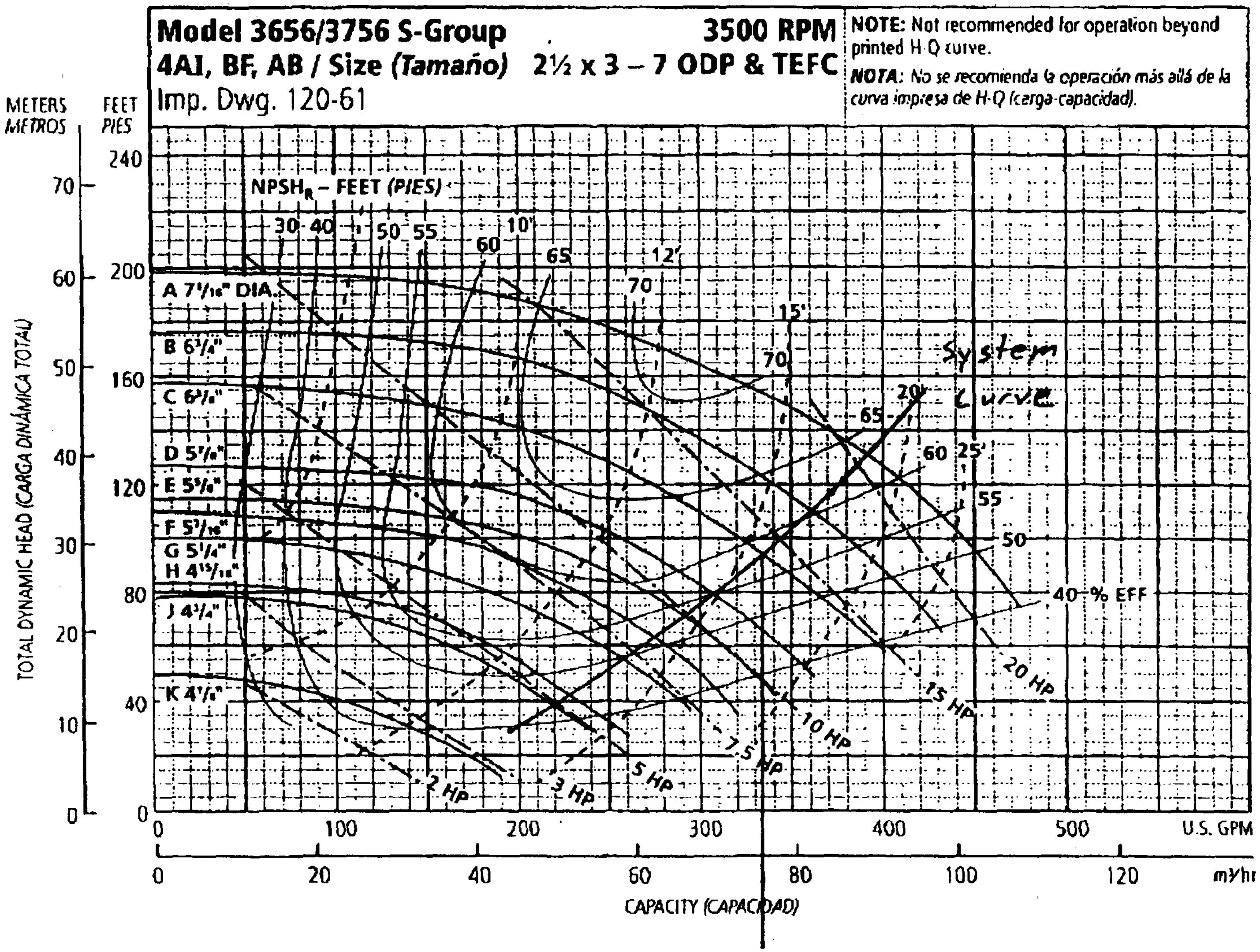
	GROUNDWATER EXTRACTION WELL
	TEMPORARY CONVEYANCE PIPE AND FLOW DIRECTION
(A)	CONVEYANCE SYSTEM LOCATION ID

NOTES

1. Temporary 4-inch HDPE pipe will be installed on ground surface except at Pillsbury Avenue boring, and through the existing underground 6-inch steel pipe east of the levee.

Golder Associates, St. Louis, Missouri	
SCALE	AS SHOWN
DATE	JAN2002
DESIGN	TML
CADD	JAP
CHECK	---
REVIEW	
FILE No.	9606.022
PROJECT No.	023-9606
REV.	1
TITLE	PUMPING SYSTEM LAYOUT
PROJECT	SAUGET AREA 2, SITE R, GMCS, SAUGET, ILLINOIS
DWG/FIG No.	1

FIGURE 2: SYSTEM CURVE FOR BOOSTER PUMP



Optional Impeller *Impulsor optativo*	
Ordering Code ***Código de pedido***	**Dia.** ***Diá.***
A	7$^1/_{16}$"
B	6$^3/_4$
C	6$^3/_8$
D	5$^7/_8$
E	5$^5/_8$
F	5$^7/_{16}$
G	5$^1/_4$
H	4$^{15}/_{16}$
J	4$^3/_4$
K	4$^1/_8$

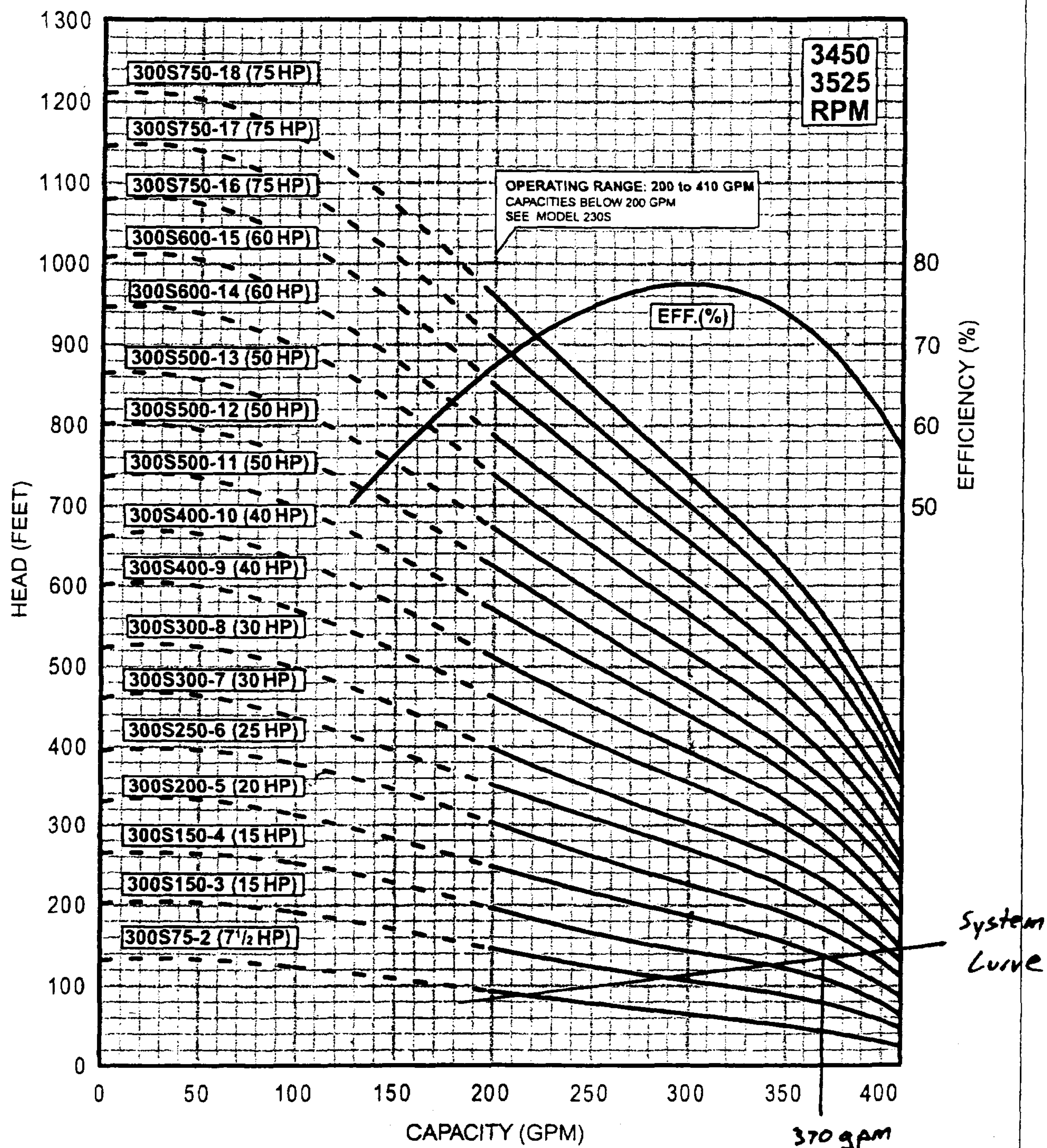
NOTE: Pump will pass a sphere to $^7/_{16}$" diameter.

NOTA: La bomba dejará pasar una esfera de hasta $^7/_{16}$ de pulgada de diámetro.

Figure 3: SYSTEM CURVE FOR WELL PUMP

Model 300S **300 GPM** **Performance Curves**

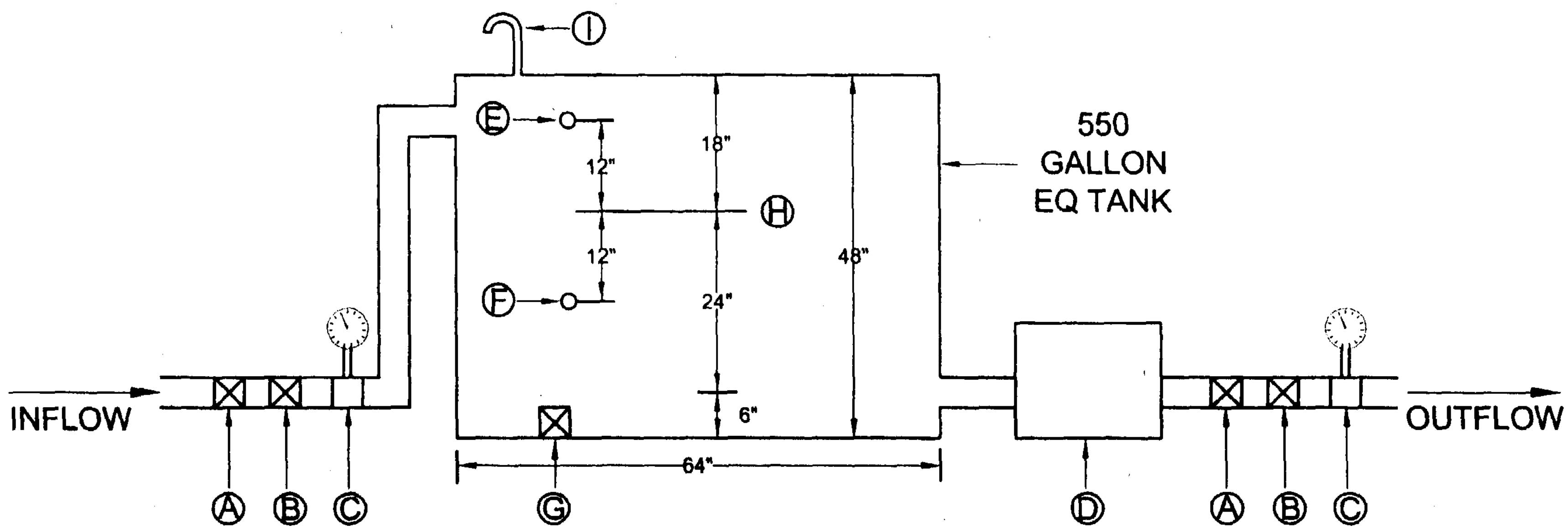
FLOW RANGE: 200 -410 GPM **OUTLET SIZE: 3"& 4" NPT*** **NOMINAL DIA. 6"**



SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE.
4" MOTOR STANDARD, 7.5 HP/3450 RPM.
6" MOTOR STANDARD,15-50 HP/3450 RPM.
8" MOTOR STANDARD, 60-75 HP/3525 RPM.
* 3" NPT 2-7 STAGES, 4" NPT 8-18 STAGES.

Performance conforms to ISO 2548 Annex B @ 8 ft. min. submergence.

GRUNDFOS



NOTES

- (A) CHECK VALVES
- (B) GATE VALVES - USED TO ADJUST INFLOW/OUTFLOW RATES
- (C) FLOW METERS - USED TO GAUGE INFLOW/OUTFLOW RATES
- (D) GOULDS 3656 - 6.375" IMPELLER, 14 HP BOOSTER PUMP
- (E) FLOAT SWITCH - WHEN WSE RISES ABOVE THIS POINT, TURN THE WELL PUMP OFF
- (F) FLOAT SWITCH - WHEN WSE FALLS BELOW THIS POINT, TURN THE BOOSTER PUMP OFF
- (G) DRAIN VALVE
- (H) IDEAL OPERATING WATER SURFACE IN THE EQ TANK WITH INFLOW AND OUTFLOW RATES BALANCED AT 300 GPM
- (I) AIR VENT

REV	DATE	DES	REV_DESC	CADD	CHK	RVW
REV	DATE	DES	REVISION DESCRIPTION	CADD	CHK	RVW

PROJECT

SAUGET AREA 2, SITE R, GMCS
SAUGET, ILLINOIS

TITLE

EQUILIZATION TANK AND BOOSTER PUMP DETAIL

Golder Associates
OFFICE_PROV/STATE

PROJECT No.	PROJECT_NO		FILE No.	---
DESIGN	DESIGN	TML	SCALE	SCALE / REV. REV
CADD	CADD	JAP	DWG/FIG No.	4
CHECK	CHECK	---		
REVIEW	REVIEW	---		

ATTACHMENTS

Solutia / Extraction Well R / IL
System Details
Project #: 023-9606
By: TML

ATTACHMENT 1: SYSTEM LAYOUT

Information provided was assimilated to provide the following geometric measurements that are used in conjunction with **Figure 1** for the pump system.

Note: the chosen datum is the ground elevation at groundwater extraction well EW2 (0.0 ft).

Identified Location	Elevation Relative to Datum (ft)	Distance to next Location (ft)	Location Notes
A	0.0	900	Groundwater extraction well EW2 (sudden contraction + 90° vertical bend)
B	8.5	10	Filter system (two 90° vertical bends + sudden expansion at eq. tank)
C	5.0	115	Booster pump (suction side - sudden contraction - draws from eq. tank)
D	8.0	475	First 90° horizontal bend on southern edge of Riverview drive
E	7.5	390	Gate on Riverview drive
F	10.5	100	Second 90° horizontal bend on southern edge of Riverview drive
G	10.5	38	Start of Pillsbury Ave. bore (90° horizontal bend)
H	0.5	38	Middle of Pillsbury Ave. bore
I	11.5	115	End of Pillsbury Ave. bore
J	16.0	5	Adjacent to levee wall
K	19.0	23	Top of levee wall (two 90° vertical bends between J and K)
L	16.0	10	East edge of levee road (two 90° vertical bends between K and L)
M	13.0	70	Start of 6" steel pipe (sliplined with 4" HDPE)
N	-4.0	260	Underground 6" steel pipe at bottom of slope
O	-5.0	5	End of underground 6" steel pipe (90° vertical bend)
P	0.0	300	Ground surface above end of underground 6" steel pipe (90° vertical bend)
Q	2.0	6	Intersection with discharge manhole: start of drop pipe (90° vertical bend)
R	-4.0	---	Intersection with discharge manhole: end of drop pipe (sudden expansion)

ATTACHMENT 2: SYSTEM CURVE FOR BOOSTER PUMP

The system curve for the booster pump is created by solving the energy equation for the pump head added to the system at various flows.

Assume:

1) Kinetic energy correction factor α = 1.0 on both sides of the energy equation.
2) The water surface elevation in the equilization tank lies 7 feet above the datum.
3) The datum is assumed to be ground surface at the well.
4) The pipeline consists of 4 inch diameter HDPE pipe with a Hazen-Williams coefficient C = 155.
5) The bend loss coefficient of all 90° bends is K_b = 0.2.
6) The expansion loss coefficient is K_e = 1.0.
7) The contraction loss coefficient is K_c = 0.5.
8) The minor loss coefficient is K_l = 0.2.

Pumping Rate		Pipeline		Velocity Head		Pressure Head		Elevation		Bend Losses			Expansion Losses			Contraction Losses			Minor Losses			Friction Losses			Calculated
Q (gpm)	Q (cfs)	Diameter (ft)	Velocity (ft/s)	at Eq. Tank (ft)	at Outlet (ft)	at Eq. Tank (ft)	at Outlet (ft)	at Eq. Tank (ft)	at Outlet (ft)	Number of 90° Bends	Coeff. K_b	Bend Loss h_b (ft)	Number of Sudden Expansions	Coeff. K_e	Exp. Loss h_e (ft)	Number of Sudden Contractions	Coeff. K_c	Cont. Loss h_c (ft)	Number of Minor Losses	Coeff. K_l	Minor Loss h_l (ft)	Pipeline Length (ft)	HW Coeff. C	Friction Loss h_f (ft)	Pump Head h_p (ft)
200	0.446	0.33	5.1	0.0	0.0	0.0	0.0	5.0	-4.0	10	0.2	0.8	1	1.0	0.4	1	0.5	0.2	3	0.2	0.2	1950	155	38.4	31
220	0.490	0.33	5.6	0.0	0.0	0.0	0.0	5.0	-4.0	10	0.2	1.0	1	1.0	0.5	1	0.5	0.2	3	0.2	0.3	1950	155	45.8	39
240	0.535	0.33	6.1	0.0	0.0	0.0	0.0	5.0	-4.0	10	0.2	1.2	1	1.0	0.6	1	0.5	0.3	3	0.2	0.3	1950	155	53.8	47
260	0.579	0.33	6.6	0.0	0.0	0.0	0.0	5.0	-4.0	10	0.2	1.4	1	1.0	0.7	1	0.5	0.3	3	0.2	0.4	1950	155	62.3	56
280	0.624	0.33	7.1	0.0	0.0	0.0	0.0	5.0	-4.0	10	0.2	1.6	1	1.0	0.8	1	0.5	0.4	3	0.2	0.5	1950	155	71.5	66
300	0.668	0.33	7.7	0.0	0.0	0.0	0.0	5.0	-4.0	10	0.2	1.8	1	1.0	0.9	1	0.5	0.5	3	0.2	0.5	1950	155	81.2	76
320	0.713	0.33	8.2	0.0	0.0	0.0	0.0	5.0	-4.0	10	0.2	2.1	1	1.0	1.0	1	0.5	0.5	3	0.2	0.6	1950	155	91.5	87
340	0.758	0.33	8.7	0.0	0.0	0.0	0.0	5.0	-4.0	10	0.2	2.3	1	1.0	1.2	1	0.5	0.6	3	0.2	0.7	1950	155	102.4	98
360	0.802	0.33	9.2	0.0	0.0	0.0	0.0	5.0	-4.0	10	0.2	2.6	1	1.0	1.3	1	0.5	0.7	3	0.2	0.8	1950	155	113.8	110
380	0.847	0.33	9.7	0.0	0.0	0.0	0.0	5.0	-4.0	10	0.2	2.9	1	1.0	1.5	1	0.5	0.7	3	0.2	0.9	1950	155	125.8	123
400	0.891	0.33	10.2	0.0	0.0	0.0	0.0	5.0	-4.0	10	0.2	3.2	1	1.0	1.6	1	0.5	0.8	3	0.2	1.0	1950	155	138.3	136

Overlaying the system curve on the pump curve for the selected booster pump (Goulds 3656 - 6.375" impeller, 14 hp) in Figure 2
it can be seen that the operating point for this system is: 335 gpm.

The HDPE pipeline can withstand a line pressure of: 80.0 psi

Check the line pressure at selected locations along the pipeline to ensure that this limit is not exceeded.

Location ID	Pumping Rate		Pipeline		Velocity Head		Elevation		Bend Losses			Expansion Losses			Contraction Losses			Minor Losses			Friction Losses			Supplied	Pressure Head		Pressure
	Q (gpm)	Q (cfs)	Diameter (ft)	Velocity (ft/s)	at Eq. Tank (ft)	at Sel. Location (ft)	at Eq. Tank (ft)	at Sel. Location (ft)	Number of 90° Bends	Coeff. K_b	Bend Loss h_b (ft)	Number of Sudden Expansions	Coeff. K_e	Exp. Loss h_e (ft)	Number of Sudden Contractions	Coeff. K_c	Cont. Loss h_c (ft)	Number of Minor Losses	Coeff. K_l	Minor Loss h_l (ft)	Pipeline Length (ft)	HW Coeff. C	Friction Loss h_f (ft)	Pump Head h_p (ft)	at Eq. Tank (ft)	at Sel. Location (ft)	at Sel. Location (psi)
D	335	0.746	0.33	8.6	0.0	1.1	5.0	8.0	1	0.2	0.2	0	1.0	0.0	1	0.5	0.6	3	0.2	0.7	115	155	5.9	95	0.0	83.8	36.3
E	335	0.746	0.33	8.6	0.0	1.1	5.0	7.5	1	0.2	0.2	0	1.0	0.0	1	0.5	0.6	3	0.2	0.7	590	155	30.2	95	0.0	60.1	26.0
F	335	0.746	0.33	8.6	0.0	1.1	5.0	10.5	2	0.2	0.5	0	1.0	0.0	1	0.5	0.6	3	0.2	0.7	980	155	50.1	95	0.0	36.9	16.0
G	335	0.746	0.33	8.6	0.0	1.1	5.0	10.5	3	0.2	0.7	0	1.0	0.0	1	0.5	0.6	3	0.2	0.7	1080	155	55.2	95	0.0	31.6	13.7
H	335	0.746	0.33	8.6	0.0	1.1	5.0	0.5	3	0.2	0.7	0	1.0	0.0	1	0.5	0.6	3	0.2	0.7	1118	155	57.1	95	0.0	39.6	17.2
I	335	0.746	0.33	8.6	0.0	1.1	5.0	11.5	3	0.2	0.7	0	1.0	0.0	1	0.5	0.6	3	0.2	0.7	1156	155	59.1	95	0.0	26.7	11.6
J	335	0.746	0.33	8.6	0.0	1.1	5.0	16.0	3	0.2	0.7	0	1.0	0.0	1	0.5	0.6	3	0.2	0.7	1271	155	65.0	95	0.0	16.3	7.1
K	335	0.746	0.33	8.6	0.0	1.1	5.0	19.0	5	0.2	1.1	0	1.0	0.0	1	0.5	0.6	3	0.2	0.7	1276	155	65.2	95	0.0	12.6	5.5
L	335	0.746	0.33	8.6	0.0	1.1	5.0	16.0	7	0.2	1.6	0	1.0	0.0	1	0.5	0.6	3	0.2	0.7	1299	155	66.4	95	0.0	14.0	6.1
M	335	0.746	0.33	8.6	0.0	1.1	5.0	13.0	7	0.2	1.6	0	1.0	0.0	1	0.5	0.6	3	0.2	0.7	1309	155	66.9	95	0.0	16.5	7.1
N	335	0.746	0.33	8.6	0.0	1.1	5.0	-4.0	7	0.2	1.6	0	1.0	0.0	1	0.5	0.6	3	0.2	0.7	1379	155	70.4	95	0.0	29.9	13.0
O	335	0.746	0.33	8.6	0.0	1.1	5.0	-5.0	8	0.2	1.8	0	1.0	0.0	1	0.5	0.6	3	0.2	0.7	1639	155	83.7	95	0.0	17.4	7.5
P	335	0.746	0.33	8.6	0.0	1.1	5.0	0.0	9	0.2	2.0	0	1.0	0.0	1	0.5	0.6	3	0.2	0.7	1644	155	84.0	95	0.0	11.9	5.2
Q	335	0.746	0.33	8.6	0.0	1.1	5.0	2.0	10	0.2	2.3	0	1.0	0.0	1	0.5	0.6	3	0.2	0.7	1944	155	99.3	95	0.0	-5.6	-2.4
R	335	0.746	0.33	8.6	0.0	1.1	5.0	-4.0	10	0.2	2.3	0	1.0	0.0	1	0.5	0.6	3	0.2	0.7	1950	155	99.6	95	0.0	0.1	0.0

References:
Lindeburg, M. R. 2001. *Civil Engineering Reference Manual, 8th Edition*. Belmont, CA: Professional Publications, Inc.

Roberson, J. A., Cassidy, J. J., and Chaudhry, M.H. 1995. *Hydraulic Engineering*. New York, NY: John Wiley & Sons, Inc.

Solutia / Extraction Well R / IL
System Details
Project #: 023-9606
By: TML

ATTACHMENT 3: SYSTEM CURVE FOR WELL PUMP

The system curve for the well pump is created by solving the energy equation for the pump head added to the system at various flows. In addition, it will be necessary to solve for the drawdown in the well the pump draws from.

Assume:

1) Kinetic energy correction factor $\alpha = 1.0$ on both sides of the energy equation.
2) The aquifer feeding the well is unconfined with a hydraulic conductivity of $k = 0.1$ cm/s.
3) The well is 6 inches in diameter ($r_1 = 0.25$ feet).
4) The undisturbed groundwater table lies 30 feet below the ground surface at the well.
5) The groundwater table is undisturbed at $r_2 = 1775$ feet away from the well.
6) The datum is assumed to be ground surface at the well
7) The water surface elevation in the equilization tank lies 7 feet above the datum
8) The pipeline consists of 4 inch diameter HDPE pipe with a Hazen-Williams coefficient C = 155
9) The bend loss coefficient of all 90° bends is $K_b = 0.2$.
10) The expansion loss coefficient is $K_e = 1.0$.
11) The contraction loss coefficient is $K_c = 0.5$.
12) The minor loss coefficient is $K_l = 0.2$.
13) The head loss caused by the mobile treatment plant is assumed to equal 30 feet.

Pumping Rate		Hydraulic Conductivity		Well	Pipeline		Velocity Head		Pressure Head		Elevation		Bend Losses			Expansion Losses			Contraction Losses			Minor Losses			Friction Losses			Mobile	Calculated
Q (gpm)	Q (cfs)	k (cm/s)	k (ft/s)	Drawdown (ft)	Diameter (ft)	Velocity (ft/s)	at Well (ft)	at Eq. Tank (ft)	at Well (ft)	at Eq. Tank (ft)	at Well (ft)	at Eq. Tank (ft)	Number of 90° Bends	Coeff. K_b	Bend Loss h_b (ft)	Number of Sudden Expansions	Coeff. K_e	Exp. Loss h_e (ft)	Number of Sudden Contractions	Coeff. K_c	Cont. Loss h_c (ft)	Number of Minor Losses	Coeff. K_l	Minor Loss h_l (ft)	Pipeline Length (ft)	HW Coeff. C	Friction Loss h_f (ft)	Filter Loss h_{filter} (ft)	Pump Head h_p (ft)
200	0.446	0.10	3.28E-03	3.3	0.33	5.1	0.0	0.0	0.0	-1.5	-33.3	8.5	3	0.2	0.2	1	1.0	0.4	1	0.5	0.2	3	0.2	0.2	910	155	17.9	30	89
220	0.490	0.10	3.28E-03	3.6	0.33	5.6	0.0	0.0	0.0	-1.5	-33.6	8.5	3	0.2	0.3	1	1.0	0.5	1	0.5	0.2	3	0.2	0.3	910	155	21.4	30	93
240	0.535	0.10	3.28E-03	4.0	0.33	6.1	0.0	0.0	0.0	-1.5	-34.0	8.5	3	0.2	0.3	1	1.0	0.6	1	0.5	0.3	3	0.2	0.3	910	155	25.1	30	98
260	0.579	0.10	3.28E-03	4.3	0.33	6.6	0.0	0.0	0.0	-1.5	-34.3	8.5	3	0.2	0.4	1	1.0	0.7	1	0.5	0.3	3	0.2	0.4	910	155	29.1	30	102
280	0.624	0.10	3.28E-03	4.7	0.33	7.1	0.0	0.0	0.0	-1.5	-34.7	8.5	3	0.2	0.5	1	1.0	0.8	1	0.5	0.4	3	0.2	0.5	910	155	33.4	30	107
300	0.668	0.10	3.28E-03	5.0	0.33	7.7	0.0	0.0	0.0	-1.5	-35.0	8.5	3	0.2	0.5	1	1.0	0.9	1	0.5	0.5	3	0.2	0.5	910	155	37.9	30	112
320	0.713	0.10	3.28E-03	5.4	0.33	8.2	0.0	0.0	0.0	-1.5	-35.4	8.5	3	0.2	0.6	1	1.0	1.0	1	0.5	0.5	3	0.2	0.6	910	155	42.7	30	118
340	0.758	0.10	3.28E-03	5.7	0.33	8.7	0.0	0.0	0.0	-1.5	-35.7	8.5	3	0.2	0.7	1	1.0	1.2	1	0.5	0.6	3	0.2	0.7	910	155	47.8	30	124
360	0.802	0.10	3.28E-03	6.1	0.33	9.2	0.0	0.0	0.0	-1.5	-36.1	8.5	3	0.2	0.8	1	1.0	1.3	1	0.5	0.7	3	0.2	0.8	910	155	53.1	30	130
380	0.847	0.10	3.28E-03	6.4	0.33	9.7	0.0	0.0	0.0	-1.5	-36.4	8.5	3	0.2	0.9	1	1.0	1.5	1	0.5	0.7	3	0.2	0.9	910	155	58.7	30	136
400	0.891	0.10	3.28E-03	6.8	0.33	10.2	0.0	0.0	0.0	-1.5	-36.8	8.5	3	0.2	1.0	1	1.0	1.6	1	0.5	0.8	3	0.2	1.0	910	155	64.6	30	143

Overlaying the system curve on the pump curve for the selected well pump (Grundfos Model 300S200-5: 20 hp) in Figure 3
It can be seen that the operating point for this system is: 370 gpm

The mobile filter unit can withstand a line pressure of: 50.0 psi

Check the line pressure immediately upstream of the mobile filter plant.

Pumping Rate		Hydraulic Conductivity		Well	Pipeline		Velocity Head		WSE		Bend Losses			Expansion Losses			Contraction Losses			Minor Losses			Friction Losses			Supplied	Pressure Head		Pressure
Q (gpm)	Q (cfs)	k (cm/s)	k (ft/s)	Drawdown (ft)	Diameter (ft)	Velocity (ft/s)	at Well (ft)	at Mobile Filter Plant (ft)	at Well (ft)	at Mobile Filter Plant (ft)	Number of 90° Bends	Coeff. K_b	Bend Loss h_b (ft)	Number of Sudden Expansions	Coeff. K_e	Exp. Loss h_e (ft)	Number of Sudden Contractions	Coeff. K_c	Cont. Loss h_c (ft)	Number of Minor Losses	Coeff. K_l	Minor Loss h_l (ft)	Pipeline Length (ft)	HW Coeff. C	Friction Loss h_f (ft)	Pump Head h_p (ft)	at Well (ft)	at Mobile Filter Plant (ft)	at Mobile Filter Plant (psi)
370	0.824	0.10	3.28E-03	6.2	0.33	9.4	0.0	1.4	-36.2	8.5	1	0.2	0.3	0	1.0	0.0	1	0.5	0.7	0	0.2	0.0	900	155	55.3	133	0.0	30.5	13.2

References:

Lindeburg, M. R. 2001. *Civil Engineering Reference Manual, 8th Edition*. Belmont, CA: Professional Publications, Inc.

Roberson, J. A., Cassidy, J. J., and Chaudhry, M.H. 1995. *Hydraulic Engineering*. New York, NY: John Wiley & Sons, Inc.

Solutia / Extraction Well R / IL
System Details
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ATTACHMENT 4: BOOSTER & WELL PUMP EFFICIENCY

Check the water vs. brake vs. required input horsepower for the booster and well pumps.

Assume:
1) Pump efficiency = 75%.
2) Motor efficiency = 85%.

Selected Pump	Pumping Rate (gpm)	Total Dynamic Head (ft)	Water Horsepower (hp)	Pump Efficiency (%)	Brake Horsepower (hp)	Motor Efficiency (%)	Input Horsepower (hp)	Overall Efficiency (%)
Booster	335	95	8.1	75%	10.8	85%	12.7	64%
Well	370	133	12.4	75%	16.6	85%	19.5	64%

References:

Lindeburg, M. R. 2001. *Civil Engineering Reference Manual, 8th Edition*. Belmont, CA: Professional Publications, Inc.

Roberson, J. A., Cassidy, J. J., and Chaudhry, M.H. 1995. *Hydraulic Engineering*. New York, NY: John Wiley & Sons, Inc.